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Use Of Colour Doppler Ultrasonography In Early Assessment Of Dialysis Access Complications In Patients Undergoing Surgery For Hemodialysis Access

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Abstract

Objective: A majority of patients all over the world with renal failure in the late stage of the disease need regular hemodialysis for maintaining a good quality of life. Making an arterio-venous (AV) fistula is the most common way to have vascular access for doing hemodialysis in these patients. Our study aimed to see the use of colour Doppler ultrasound (CDU) in the early diagnosis of ischemic steal syndrome (ISS) in patients with AV fistula for hemodialysis.

Methods: We conducted this study in the Nephrology and Radiology departments of Fauji Foundation Hospital, Rawalpindi. The study was a prospective, cross-sectional trial conducted on sixty patients of chronic renal failure who were on hemodialysis and advised to have an arterio-venous fistula in the upper extremity. Patients had having age range in age from 20 to 70 years. Colour Doppler ultrasound was done, and assessment of the line and its complications along with PSV (Peak Systolic Velocity) and EDV (End Diastolic Volume) measurement was done by an expert Radiologist.. The proximal, mid, and distal outflow veins were examined for patency, diameters, and mean velocities. The extent of the stenosis was calculated where there was stenosis.

Results: The Majority of the patients had normal vessel calibre, with 13 patients (21.6%) having a BB fistula, 15 patients (25%) having an RC fistula, and 32 patients (53%) having a BC fistula. Our study had shown a mean age of AVF maturation of 3.07 ± 0.389 weeks after its 1st creation. Five patients (8.3%) had an uncomplicated outcome, and 55 patients (91.6%) had a shunt complication of 90%. A significant venous thrombosis was seen in 24 patients(40%), stenosis in 18 patients(30%), aneurysmal dilatation in 12 patients(20%), pseudo-aneurysmal formation in 6 patients(10%) and last but not least steal syndrome in 2 patients(3.3%,).

Conclusion: Early recognition and management of an abnormal fistula in hemodialysis patients can improve the outcome in chronic renal failure patients and reduce the incidence of ischemic steal syndrome and other complications.

Keywords: Colour Doppler Ultrasonography, Hemodialysis, AV fistula, Ischemic steal syndrome

Introduction

Worldwide, individuals experiencing end-stage renal disease (ESRD) depend heavily on hemodialysis to survive for a longer period. Arterio-venous fistulas are necessary to keep them on long-term dialysis.. Dialysis access is most commonly obtained in the upper extremities. By joining a vein to an artery (AV fistula or AVF) or by inserting a conduit, typically made of synthetic material, across an artery and a vein (AV graft or AVG), an arterio-venous access (AVA) is made. This will make a high-flow circuit, which, when mature, can be approached percutaneously for cannulation to do hemodialysis. A properly constructed and functional vascular access provides good flow of blood, excellent patency, and easy access for multiple cannulations by using two needles. The arterio-venous fistula (AVF) provides long-term vascular access with lower mortality and morbidity. Yet, arterio-venous grafts remain clinically important in older individuals in whom making an AVF is difficult. In making an AV fistula, the vein is distended surgically, and then this fistula goes through a remodelling process called maturation. Although these modifications take

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S.M.C, B.B, K.K, T.H - Conception of study - Experimentation/Study Conduction
G.M, K.F - Analysis/Interpretation/Discussion
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place variably, but mostly take place relatively quickly, leading to a formation of a fistula that may be used multiple times to do a proper procedure of hemodialysis, After doing this procedure regular monitoring is advised as early detection and treatment of access dysfunction can result in lowering the access failure rate. Colour Doppler Ultrasound is the primary imaging method for evaluating dialysis access circuits as they are superficial and easily accessed by experienced radiologists. Before doing surgical process of AV fistula, vascular mapping is done with Colour Doppler Ultrasonography (CDU). Moreover, CDU is also valuable in deciding the proper time for puncture, an earlier detection of any complication and in deciding the appropriate method for correction of the complication. Therefore, CDU is a very useful modality with low cost, easily available, non-invasive and without any hazard of using ionising radiation or iodinated contrast medium. Our study was to assess the use of Colour Doppler Ultrasound in the assessment of patients with chronic renal failure on hemodialysis preoperatively for vascular mapping, in guiding for formation of arterio-venous fistula (AVF), in assessing the process of AVF maturation and in early detection of any complications related to the shunt.

Materials And Methods

We conducted this prospective, cross-sectional trial at Fauji Foundation Hospital Rawalpindi in the departments of Nephrology and Radiology from December 2023 to November 2024. Sixty patients with an age range of 20 to 70 years and both male and female, were recruited for the study. Patients presenting in the Nephrology Department with end-stage renal disease and needing an AV fistula in the upper limb, with a malfunctioning AV fistula and patients in need of a new fistula at another site for hemodialysis were included in the trial. Patients with multiple co-morbid conditions, patients with hypotension and patients who were refused a hemodialysis procedure for any reason were excluded from the study. All patients were informed about the process for consent, keeping in mind the conscious level, and in case of a semiconscious state, proxy consent from an immediate relative was taken. A comprehensive history was obtained by interviewing the patient or relative, and a review of previous medical records was done regarding medical state, previous operations or invasive procedures, past and present drugs, recent or prior manipulation on fistula/graft limb any history of venous thrombosis.

Before doing CDU, patients were assessed clinically for dialysis access by feeling thrill, strength and consistency to determine the access patency, any areas of swelling and redness, collateral vessels and dilatation. Colour Doppler ultrasound machines featuring high-frequency transducers (8e10 MHz) were used to perform CDU examinations, with the patient's position optimised so that gravity can aid in vein dilation. Examinations comprised afferent arteries, the site of anastomosis, the draining venous vessels up to the subclavian vein and finally the arterial tree distal to the AVF in patients with steal syndrome. Grayscale and colour Doppler images of vessels in both longitudinal and transverse planes in B-mode were used for identifying the type and site of fistula, wall echoes pattern, dilations, and vessel diameter measurement. Afterwards, colour images evaluated the direction of blood flow and finally, Doppler studies were done in longitudinal orientation, adjusting the wall filter to 50e100 Hz. Spectral waveforms were taken at each level as arterial diameter 2 cm proximal to the site of the fistula, fistula diameter, PSV (Peak Systolic Velocity) and EDV (End Diastolic Volume). The proximal, mid, and distal outflow veins were examined for patency, diameters, and mean velocities. The extent of the stenosis was calculated when there was stenosis. Stenosis was diagnosed when the diameter of the vessel decreased by more than 50% and the PSV ratio increased to more than 2:1 in the vein that drains or more than 3:1 in the anastomotic region.

Signs and Symptoms of an Insufficient A-V Fistula were taken as poor arterial flow with hemodialysis, distal tingling, numbness or pain during dialysis, thrill sensation, clinical suspicion of infection and dilated superficial veins. Upon CDU parameters noted were as site of fistula, type of fistula, afferent artery, arterial wall echo pattern, draining vein, diameter of fistula, distance of fistula from skin, echogenic thrombus formation, aneurysm, pseudo-aneurysm, stenosis, hematoma, and steal phenomena or syndrome. The Statistical analysis was done using SPSS version 22 and was used to code, process and analyse the obtained data. Whether the data was normally distributed, the Shapiro-Wilk test was used, and frequencies with relative percentages were applied to represent qualitative data. The chi-square test was used to determine the difference between two or more sets of qualitative variables. Quantitative data have been presented as mean ± SD (Standard deviation). A p-value of less than 0.05 has been regarded as significant.

Results

Our study was done on 60 patients after proper pre-trial assessment and after fulfilling the inclusion criteria. The mean age of patients was 45.84 ± 8.72 (Mean ± SD), with a minimum of 20 and a maximum of 70 years old. Twenty-eight of our sample patients were males and 32 were females. Among 60 patients with end stage renal disease and being evaluated for AVF, 48 patients (80%) presented with poor flow in arteries, 30 patients (50%) have no thrill sensations, 18 (30%) patients showed very week thrill sensation, 2 patients (3.3%) showed distal tingling, numbness and pain while on hemodialysis, 30 patients (50%) had impaired

fistula and 18 patients (30%) had week impaired fistula, 2 patients (3.3%) showed clinical signs of infection and 10 patients (16.7%) had dilated superficial veins as shown in (Table 1).

Table 1: Different complications of AV fistula in patients

Patient Variables	Numbers
Poor arterial flow with hemodialysis	
Absent	12(20)
Present	48(80)
Adequate	12(20)
Thrill Sensation	
No	30(50)
Week	18(30)
Distal tingling, numbness and pain during hemodialysis	
Weak	58(96.7)
Present	2(3.3)
Absent	12(20)
Impaired fistula	
Week	18(30)
Yes	30(50)
Clinical suspicion of infection	
No	58(96.7)
Yes	2(3.3)
Dilated superficial veins	
No	50(83.3)
Yes	10(16.7)

Among sixty patients, regarding the fistula type, 12 patients (20%) had brachio-basilic, 2 patients (3.3%) had brachio-brachial, 30 patients (50%) had brachio-cephalic, and 16 patients (26.7%) had radio-cephalic fistula. Regarding the draining vein, 12 patients (20%) had basilic vein, 2 patients (3.3%) had brachial vein, and 46 patients (67.6%) had cephalic vein. Regarding the afferent artery, 44 patients (73.3%) had the brachial artery, and 16 patients (26.7%) had the radial artery (Table 2).

Table 2: AVF types of the study patients

Patient Variables	Numbers
Brescia-cimino	30(50)
Site of fistula	
Brachio-brachial	48(80)
Upper arm basilic	12(20)
Upper arm cephalic	12(20)
Brachio-basilic	12(20)
Type of fistula	
Brachio-brachial	30(50)
Brachio-cephalic	18(30)
Radio-cephalic	
Basilic	
Draining vein	
Brachial	58(96.7)
Cephalic	2(3.3)
Afferent artery	
Brachial	18(30)
Radical	30(50)

Additionally, 18 patients (30%) had weak blood flow, 30 patients (50%) had abnormal blood flow, 6 patients (10%) had a Yin-yang pattern, 46 patients (67%) had a black zone in the lumen, 30 patients (50%) were aliasing, and 2 patient (3.5%) had abnormal results in examination of the distal arterial tree where PSV decreased in patients experiencing steal syndrome and increased with occluded fistula. The total complications frequencies were 48 among 60 patients, venous thrombosis was found in 24 patients (40%), stenosis was found in 18 patients (30%), aneurysm was found in 12 patients (20%), pseudo-aneurysm was found in 6 patients (10%), hematoma in 4 patients (6.7%), clinical signs of infection were found in 2 patients (3.3%), and steal phenomenon/syndrome was found in 2 patients (3.3%).

Among 60 patients with Color Doppler Ultrasonographic evaluation through specific parameters including, mean of diameter fistula 8.90 ± 13.121 (Mean ± SD) with minimum 4 mm and maximum 39 mm, distance of fistula from skin 7.56 ± 3.272 (Mean ± SD) with minimum 4 mm and maximum 28 mm, PSV 24.55 ± 28.723 (Mean ± SD) with minimum 0 cm/s and maximum 90 cm/s, Time Averaged Mean Velocity 22.20 ± 29.725 (Mean ± SD) with minimum 0 cm/s and maximum 80 cm/s and blood flow volume rate 349.88 ± 732.409 (Mean ± SD) with minimum 0 ml/ min and maximum 4775 ml/min

Table 3: Parameters of AVF of study patients by Colour Doppler Ultrasonography

Parameters	Mean	SD	Median	IQR
Diameter of fistula	8.90	13.121	5	4-6.4
Distance of the fistula from the skin	7.56	3.272	5	4-6
PSV (Peak Systolic Velocity)	24.55	28.723	18	0-41.5
TAMV (Time average mean velocity)	22.20	29.725	15.9	0-42.5
Blood flow volume, ml/min	349.88	732.409	152	0-378

Discussion

Vascular access problems remain the vulnerable point of modern care of patients with renal failure on hemodialysis. For evaluation of dialysis access dysfunction, the most important, practical and cost-effective initial method is to do a physical examination of the fistula site. Colour Doppler Ultrasonography confirms the results of physical examination, like inflow and outflow stenosis. Moreover, it also gives important information about the functional severity, like brachial artery flow rates. By combining the results of Doppler ultrasound and physical examination, the treatment methods can be determined, such as angioplasty, revision surgery, or conservative management. Therefore, by the use of Doppler ultrasonography, more clinical problems and needs are satisfied. In this study, we evaluated the clinical utility of CDU for the early detection of complications in AV dialysis access.

In our study population, we found complications in patients on hemodialysis as access venous thrombosis in forty per cent and stenosis in thirty patients. In our trial, thrombosis was found at the anastomosis site and on the venous side of the fistula. Venous thrombosis was picked with the absence of flow, utilising Colour or Pulsed Doppler, with the presence of an echogenic or hypo-echoic thrombus which filled the lumen. In an arterio-venous fistula, increased blood flow due to pressure increase results in an increase in vessel size. When in a fistula, there is a significant amount of aneurysmal dilatation, downhill venous stenosis is always suspected and often associated with thrombosis. In these patients, skin thinning should be carefully evaluated as it may result in serious bleeding, ulcer formation and sometimes even rupture. An increase in the calibre of a vessel to greater than 2 cm is considered one of the most characteristic ultrasonographic features of venous aneurysm. Pseudo-aneurysms are also common (around 10%), which occur at the anastomoses or the puncture sites. While an arterio-venous fistula is punctured either spontaneously during dialysis or due to some intervention, it sometimes results in persistent haemorrhage and the formation of pseudo-aneurysms. Although it is less clear why these true aneurysms are formed in arterio-venous fistulas but it could be due to repetitive needling resulting in the creation of numerous small fibrous scars in vessel walls, which can expand over time and produce localised aneurysmal regions. Although aneurysms and pseudo-aneurysms are properly diagnosed based on clinical findings of a pulsatile mass along with a systolic murmur, CDU also allow better estimation of size and extent of aneurysm, its neck dimensions and degree of mural thrombosis. In addition, CDU can also differentiate between pseudo-aneurysms and hematomas by the typical “to-and-fro” pattern.

In a study done in Lebanon, 30% of patients had aneurysms and pseudo-aneurysms, and Colour Doppler Ultrasonography was useful in assessing the extent of aneurysm along with luminal thrombus formation as well as the need for surgery. In our study subclavian steal phenomenon or syndrome occurred in approximately 2% of patients and frequently occurs in fistulas with big anastomoses and lots of flow. Signs and symptoms of this syndrome are, in milder cases as pallor, paresthesia, cold limbs and pain during dialysis. While severe cases present as pain at rest, palsy, ulceration, necrosis and loss of tissues.

Steal syndrome is defined as the radial artery section distal to the arterio-venous fistula anastomosis shows flow inversion. It will result in the stealing of blood by fistula from the hand/palmar arch. In both colour and pulsed mapping, this is diagnosed by marked reduction in blood flow or reversal of flow via the arterial segment distal to the arterio-venous fistula. As there is no compensation for peripheral arterial perfusion, gradually, this steal phenomenon will become a steal syndrome. Age more than 60 years, diabetes mellitus, and female gender constitute risk factors for steal syndrome. The steal syndrome is characterised by acral necrosis, loss of tissues, ulcerations, pain at rest and pain during hemodialysis sessions. The main problem is to identify patients at risk of access-induced ischemic steal syndrome by use of Colour Doppler Ultrasound before creating the fistula. In a study done in Jordan, the Peak Systolic Velocity of the ulnar and radial arteries was decreased as the fistula became functional and later increased when it got blocked. As the velocity ratio is defined as PSV fistula blocked/PSV fistula working exceeded, steal syndrome was considered to develop. The majority of complications of AVF are infections and among which perivascular cellulitis is the most common, presenting as localised erythema and oedema, which can be easily treated. Infections related to some anatomical defects are even more serious, like aneurysms, hematomas, or abscesses need immediate surgical removal and drainage. When there is hematoma

formation complicated by active haemorrhage or not also needs immediate surgical intervention, as a fistula could not be impacted by a hematoma if there was no active haemorrhage through the sutures. In the presence of a small hematoma and arterio-venous thrill, no surgical intervention is needed as the patient continues to be monitored. If there is a large hematoma along with thrill, it must be immediately evacuated with closure of the haemorrhage source and the repermeation of arterio-venous fistula. Sometimes removing the hematoma results in restoration of normal thrill, and if this doesn't work, the fistula can be closed, and a new AVF should be constructed.

Conclusions

Colour Doppler Ultrasonography is a noninvasive modality to assess the anatomy and hemodynamics of arterio-venous fistula in patients with chronic renal failure on hemodialysis. This procedure can be easily done at the bedside, is relatively inexpensive and without no major side effects. The arterio-venous fistula lumen is accessed with CDU and is also used to measure the dimensions and luminal encroachments. This modality is also effective in guiding surgeons to have arterio-venous fistula reconstruction rather than making a new shunt.

References

1. Abou-Rashed AA, Tawfik MH, Ayoub HS, Elazhari AA. Role of color Doppler ultrasonography in evaluation of hemodialysis AV fistula. Al-Azhar International Medical Journal. 2023;4(3):4. https://doi.org/10.26044/ecr2020/C-14769.
2. Hassan MH, Abdelrazek GM, Hashim AA. The clinical importance of color Doppler ultrasonography in puncture related complications of hemodialysis vascular access. Egypt J Radiol Nucl Med. 2019;50:89e94. https://doi.org/10.1186/s43055-019-0087-7
3. Sohrabi C, Mathew G, Maria N, Kerwan A, Franchi T, Agha RA; Collaborators. The SCARE 2023 guideline: updating consensus Surgical CAse REport (SCARE) guidelines. Int J Surg. 2023 May 1;109(5):1136-1140. https://doi.org/10.1097/JS9.0000000000000373.
4. C.W. Hicks, S. Bae, M.E. Pozo, S.R. DiBrito, C.J. Abularrage, D.L. Segev, et al. Practice patterns in arteriovenous fistula ligation among kidney transplant recipients in the United States renal data systems. J. Vasc. Surg., 70 (3) (2019), pp. 842-852, https://doi.org/10.1016/j.jvs.2018.11.048 e1
5. Bashar AE, Abou-Rashed MA, Talaat Mohamed M. Role Of Color Doppler Ultrasonography In Assessment Of Complications Of Hemodialysis Av Fistula. Al-Azhar Medical Journal. 2023 Jul 1;52(3):869-82. https://doi.org/10.21608/amj.2023.315124
6. Cho S, Lee YJ, Kim SR. Value of Doppler evaluation of physically abnormal fistula: hemodynamic guidelines and access outcomes. The Korean Journal of Internal Medicine. 2017 Apr 18;34(1):137. https://doi.org/10.3904/kjim.2016.299
7. Atwan, E.F., Awad, A.S., Abdelrahman, S.M. et al. Surveillance and monitoring of early failing arteriovenous fistula using Doppler assessment in children on regular hemodialysis. Egypt J Radiol Nucl Med 53, 229 (2022). https://doi.org/10.1186/s43055-022-00912
8. Suraj HS, Anil Kumar S, Rachegowda N, Rajeswari GT, Yashas Ullas L, Revanth RB. Role of Doppler Evaluation in Assessing the Maturation of the Arteriovenous Fistula for Hemodialysis: An Observational Study. Cureus. 2024 Mar 4;16(3):e55527. https://doi.org/10.7759/cureus.55527.
9. Abou Diwan R, Kaadi L, Hachem S, Smayra T, Slaba S, Chalhoub B, et al. Pseudoaneurysms: Different ultrasound patterns, aetiologies and locations. Australas J Ultrasound Med. 2023 Jul 27;26(4):258-266. https://doi.org/10.1002/ajum.12348.
10. Dasari R, Karanam SP, Kumar A, Tyagi A, Kumar S, Lakshmi AY. Hemodialysis arteriovenous fistula maturation and role of perioperative vascular mapping. Journal of Dr. YSR University of Health Sciences. 2019 Oct 1;8(4):257-60. https://doi.org/10.4103/JDRNTRUHS.JDRNTRUHS_55_19
11. Suwanto D, Dewi IP, Wardhani LFK, Noor YA, Nugroho J. Recognizing dialysis access steal syndrome with central vein stenosis as arteriovenous fistula complication: A case report. Int J Surg Case Rep. 2023 Jan;102:107824. https://doi.org/10.1016/j.ijscr.2022.107824.
12. Adams A., Osman A. Dialysis access steal syndrome. J. Emerg. Nurs. 2020;46(4):524–526. https://doi.org/10.1016/j.jen.2020.01.009.
13. Liao A, Knipe H, Lim L, Dialysis access-associated steal syndrome. Reference article, Radiopaedia.org. https://doi.org/10.53347/rID-170969
14. Alqahtani SS, Aljaber FK, Alsuwailem BY, AlMashouq YA, AlHarbi BG, Elawad AM. Dialysis Access-Associated Steal Syndrome in High-Risk Patients Undergoing Surgery for Hemodialysis Access: A Systematic Review and Meta-Analysis of Preventive Operative Techniques. Cureus. 2023 Nov 28;15(11):e49612. https://doi.org/10.7759/cureus.49612.
15. Al-Jaishi AA, Liu AR, Lok CE, Zhang JC, Moist LM. Complications of the Arteriovenous Fistula: A Systematic Review. J Am Soc Nephrol. 2017 Jun;28(6):1839-1850. https://doi.org/10.1681/ASN.2016040412.
16. Rehman ZU, Durrani MY, Ishaq H, Sophie Z. Distal revascularization and interval ligation as a useful option for steal syndrome. J Coll Physicians Surg Pak. 2019;29:865–867. https://doi.org/10.29271/jcpsp.2019.09.865